Parametric Study of Carbon Nanotube Production by Laser Ablation Process

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Abstract

Carbon nanotubes form a new class of nanomaterials that are presumed to have extraordinary mechanical, electrical and thermal properties. The single wall nanotubes (SWNTs) are estimated to be 100 times stronger than steel with 1/6th the weight; electrical carrying capacity better than copper and thermal conductivity better than diamond. Applications of these SWNTs include possible weight reduction of aerospace structures, multifunctional materials, nanosensors and nanoelectronics. Double pulsed laser vaporization process produces SWNTs with the highest percentage of nanotubes in the output material. The normal operating conditions include a green laser pulse closely followed by an infrared laser pulse. Lasers ablate a metal-containing graphite target located in a flow tube maintained in an oven at 1473K with argon flow of 100 sccm at a 500 Torr pressure. In the present work a number of production runs were carried out, changing one operating condition at a time. We have studied the effects of nine parameters, including the sequencing of the laser pulses, pulse separation times, laser energy densities, the type of buffer gas used, oven temperature, operating pressure, flow rate and inner flow tube diameters. All runs were done using the same graphite target. The collected nanotube material was characterized by a variety of analytical techniques including scanning electron microscopy (SEM), transmission electron microscopy (TEM), Raman and thermo gravimetric analysis (TGA). Results indicate trends that could be used to optimize the process and increase the efficiency of the production process.